CHAPTER M1

TABLE OF CONENTS

M1.00 General

This Chapter covers all work to replace and maintain roadway delineation and pavement markings.

It includes work in the following Family/Problem areas:

- M1 Pavement Striping
- M2 Pavement Markings
- M3 Raised Pavement Markers
- M9 (portion) -- Inventory Updating

Typical work on pavement delineation and markings may include the following:

(A) Inspection of pavement delineation

(B) Layout for replacement purposes

(C) Refurbishing delineation

(D) Replacement of missing markers

(E) Cleaning of pavement delineation

(F) Repainting of red curbs where it is a state obligation (Refer to Section M1.24)

Work in the M family includes only pavement marking and delineation on the traveled way, shoulders, ramps, and auxiliary lanes. It does not include markings, legends, parking stalls, etc., in roadside rest areas, weigh stations, and other public service locations. Work in such areas should be reported to the G family, Public Facilities.

M1.01 Levels of Maintenance

(A) Inspection

A formal night inspection of all pavement delineation condition will be completed once each year. Results of the pavement delineation condition survey shall be recorded and utilized to develop the work plan. Date of restoration shall be included in the records.

(B) Pavement Stripes and Markings

Pavement stripes and markings should be renewed when, in the judgment of the supervisor, they have lost their effectiveness. The assigned supervisor shall have the primary responsibility for identifying deficiencies. All employees, however, should be instructed to report observed deficiencies.

(C) Missing or Ineffective Pavement Markers

Missing or ineffective pavement markers that significantly affect configuration of the line should be considered for replacement. Whenever possible, replacement should be scheduled in conjunction with other maintenance operations to minimize disruptions to traffic.

M1.02 Responsibility

Existing pavement delineation (maintenance) shall be replaced with identical delineation. There is to be no deviation from the standards illustrated or written in the Traffic Manual, and no traffic stripe or raised markers shall be placed except at locations indicated in that manual without consulting with District Traffic Operations. Installation orders provided by the District Traffic Operations for placement of new or modified delineation shall show the location and type on a print, signed by the District Traffic Operations Chief. Questions regarding installation orders should be directed to District Traffic Operations.

Maintenance of signs and pavement markings placed off the right of way, for roads entering the state highway, may be an obligation of the Department when they are placed primarily for the protection of traffic on the State facility. Examples are- pavement markings that support the STOP (R1) and STOP AHEAD (W17) signs. It is standard practice for the owner of the entering facility to fund the initial installation. Future maintenance costs, including clearing of trees and brush to improve visibility of signs, should be borne by the Department.

Districts are responsible for the placement and maintenance of limit lines (stop bars) at both existing and new paved approaches to a state highway. Only those “STOP” pavement markings requested by District Traffic Operations should be maintained. Districts will coordinate the work of the pavement marking and sign crews for these installations. The preceding instruction is not intended to preclude establishment of maintenance agreements whereby local agencies assume these responsibilities.

Where local governmental agencies have been delegated pavement delineation responsibilities by maintenance agreement, their performance shall conform to the standards set forth in this chapter. The State must periodically inspect delineation to assure that local agencies are maintaining acceptable standards.

M1.03 Safety

It is the responsibility of all Caltrans highway maintenance personnel to understand and follow the rules written in the Code of Safe Practices and any other safety laws, rules, Policy and Procedures, and safety guidelines, pertaining to the work being performed.

Employees shall be provided with and shall wear required personal protective equipment applicable to the work being done. Before work starts, Material Safety Data Sheets (MSDS) for any substances used shall be reviewed, and all crew members made aware of any potential toxic hazards in the work. Pavement delineation equipment, including appropriate support equipment, shall be maintained and operated in a manner that promotes good safe practices, does not pose a hazard to other employees or the general public, or to the environment.

Thermoplastic material heated in pre-heaters to excessive temperatures can flash and splatter when the material is drawn and exposed to air. Temperature gauges mounted on thermoplastic application equipment shall be checked at frequent intervals. Equipment found to have defective temperature gauges shall not be used until repaired.

While removing or applying pavement delineation, all traffic control and worker protection shall conform to Chapter 8 of this manual, Protection of Workers.

M1.04 Lay Out

The term “lay out” refers to the process of placing reference marks on the pavement to be used as a guide for locating pavement delineation on the roadway surface.

Reference marks may also occasionally be located on curbs, sidewalks, large rocks or trees. In snow areas, saw cuts in the pavement can be used to identify the location of left turn lane pockets. Pictures of pavement delineation can also provide a valuable reference for replacement in kind.

Reference marks are a guide for placement of pavement delineation and are not to be used as temporary lane line.

M1.05 Pavement Delineation on Resurfaced Areas

(A) Requirement for Replacement of Pavement Delineation

All lane line pavement delineation that has been covered must be replaced (permanent or temporary) at the end of each day's operations. The person in charge of the field operation will be responsible to take proper action to assure that the correct type of pavement delineation is placed within the required time frames.

(1) Permanent pavement delineation covered by maintenance or construction activities should be replaced within one week and shall be replaced within two weeks. In the interim, "short-term" delineation measures shall be used. See latest instructions from the Traffic Program.

(2) Temporary lane lines shall be placed before leaving the job site, if permanent delineation cannot be restored by the end of the work shift. Various types of day/night raised reflective markers are approved for short-term use. These markers are to be placed on not more than 24 foot (7.32 meters) centers on curves and tangent.

On liquid asphalt concrete patches, a temporary day/night marker, secured by butyl adhesive to a 1 foot (304.8 millimeters) piece of temporary foil-backed tape, has proven capable of staying in place while the patch cures.

(B) Specific Instructions for Placement of Signs

(1) On two lane conventional highways where no passing-zone lane line has been covered, a sign package consisting of a C18 (23) - ROAD CONSTRUCTION (ROAD WORK) AHEAD and an R63 DO NOT PASS sign shall be posted within 1000 feet (301.8 meters) of the no passing zone. A R64 - WITH CARE- should also be posted at the end of the zone.

(2) On seal coats more than two miles (3.22 kilometers) in length, the above instruction could be modified by posting a C18 (23) - ROAD CONSTRUCTION (ROAD WORK) AHEAD at each end of the job supplemented with a W71 NEXT -- MILES (KILOMETERS) black on orange plate.

If a no-passing zone is continuous throughout the seal coated area, a R63 (DO NOT PASS) sign shall be placed at the beginning of the zone and at maximum 2,000 foot (609.6 meters) intervals.

(3) Obliterated edge lines are not to be replaced with temporary dashes or reflective markers. When edge line delineation is required because of narrowing pavement or curvilinear alignment, portable delineators (guide markers) may be used to guide traffic.

(C) Delays in Placement of Permanent Pavement Delineation

It is understood that equipment breakdown, weather, or other problems may unavoidably delay placement of permanent pavement delineation. It is important that the reason for delay be documented and filed with the project files.

(D) Exceptions to the Two Week Time Limit

Exceptions to the 2 week time limit to restore permanent delineation are as follows:

(1) Cure time of pavement before placing raised markers.

(2) Winter conditions where pavement delineation cannot be maintained due to rain, snow, plowing, etc.

(3) Short patches that are less than 500 feet (152.4 meters) long on tangent alignment where the pavement is visible when entering the patch from either direction. This exception is intended for only single patches not placed in close proximity to another.

Under no circumstances shall a job site be left without at least temporary delineation and or signs as noted above.

M1.06 Pavement Delineation Removal

The acceptable methods of removing pavement delineation are horizontal rotary grinding and sandblasting.

When using either of these methods to remove legends, the entire pavement surface within the area of the legend shall be removed. Failure to remove the surface of the entire legend area can result in the former message being conveyed by the resulting scar on the pavement surface.

Paint or asphalt emulsion shall not be used to cover pavement delineation except as a temporary measure until permanent repairs can be made.

Raised markers are sometimes removed on small jobs using hand tools such as pry bars, hammer and screwdriver, or chisel. Large removal projects can best be accomplished by utilizing a special attachment on a motor grader.

M1.07 Environmental Concerns

Solvent-borne traffic paints can no longer to be used in some air basins governed by air quality control districts. Water-borne paints and thermoplastics have been developed for use in these areas.

Caltrans districts will be responsible for monitoring and acting as independent agents in dealing with local air quality control districts. The California Environmental Protection Agency (Cal/EPA) may override local district rulings.

Residue of paint from color changes or cleaning tanks is to be handled as a hazardous waste.

Paint guns shall not be purged on shoulders. Each Caltrans district should follow established procedures adopted in their area for picking up and disposing of these materials.

Current law provides that individual employees may be held personally liable for penalties assessed for willful or negligent infractions of these rules. Caltrans will take disciplinary action against employees who violate hazardous waste disposal laws, up to and including termination of employment.

M1.08 Recessed Delineation Materials

Grinding slots in the pavement and placing recessed markers and/or plastic materials in those slots has greatly extended the life of pavement delineation in some areas. Materials installed in the recessed areas include reflective pavement markers and thermoplastic. Typical areas selected for this type installation include highways with high weave/heavy traffic and snow removal conditions.

Pavement markers having an abrasion-resistant face have proven to be effective in this type installation as well as in areas subject to blowing sand.

MI.09 Longitudinal Pavement Markings

(A) Longitudinal pavement markings conform to the following basic concepts:

(1) Yellow lines delineate the separation of traffic flows in opposing directions or mark the left edge of divided highways and one way roads.

(2) White lines delineate the separation of traffic flows in the same direction or mark the right edge of roads.

(3) Broken lines are permissive in character.

(4) Solid lines are restrictive in character.

(5) Width of line indicates the degree of restriction.

(6) Solid double lines are maximum restriction.

(7) All longitudinal pavement markings shall be reflectorized except non-reflective markers and directional markings for tourists.

(B) Longitudinal pavement markings serve the following specific traffic guidance functions:

(1) Single broken white line is used to delineate the edge of a traffic lane where traffic is permitted in the same direction on both sides of the line.

(2) Single broken yellow line is used to delineate the left edge of a traffic lane where travel on the other side of the line is in the opposite direction.

(3) Single solid white line is used to delineate the edge of a traffic lane where travel in the same direction is permitted on both sides of the line, but crossing the line is discouraged. It is also used to mark the right edge line.

A wide solid white line is used for emphasis where crossing it requires unusual care. It is also used as a line to delineate turnouts, left or right turn lanes and bicycle lanes.

(4) Single solid yellow line delineates the left edge line of each roadway of divided streets or highways, one way roadways, and ramps in the direction of travel.

(5) Double yellow line consisting of a single broken yellow line and a single solid yellow line delineates a separation between traffic lanes in opposite directions where overtaking with care is permissible for traffic adjacent to the broken line and is prohibited for traffic adjacent to the solid line.

This pattern is also used to delineate a two-way left turn lane in which the solid line is placed on the outside. Traffic adjacent to the solid line may cross this marking with care only as part of a left-turn or U-turn maneuver.

(6) Double line consisting of two solid yellow lines delineates the separation between traffic lanes in opposite directions where overtaking is prohibited in both directions. It is used as a channelizing line in both directions. It is frequently used as a channelizing line in advance of an obstruction that must be passed on the right. Black paint should be used between the yellow stripes to improve definition and maintain the interior gap during repainting.

(7) Dotted line may be used to delineate the extension of a line through an intersection or an interchange area. The dotted line shall be the same color of the line it extends.

More information on this subject is included in Chapter 6, Markings, of the Traffic Manual and in the Standard Plans.

M1.10 Pavement Markings - General

Pavement markings are used to supplement traffic signs conveying messages or directions to the motorist, particularly at locations where pavement width or dense traffic prevent motorists from seeing the signs readily.

Approval of District Traffic Operations must be obtained before using other than standard markings.

District Maintenance will continue to work with District Traffic Operations to identify pavement markings that obsolete and should not be maintained. Documentation is required from District Traffic Operations before maintenance of pavement markings is waived. A District Traffic Operations Installation Order (IO) will be required prior to removal by grinding or other methods of any pavement markings.

Stencils used to place pavement markings shall be of uniform dimension. The California standard is shown in the Standard Plans, Plates A-24A through A-24E.

Additional information regarding Pavement markings is included in Chapter 6 of the Traffic Manual: Markings.

M1.11 Pedestrian Crossings

Pedestrian crosswalk markings may be placed at intersections, representing extension of sidewalk lines, or on that portion of the roadway distinctly indicated for pedestrian crossing.

Crosswalks and related pavement markings will be painted white or yellow depending on location. Refer to the Traffic Manual Chapters 6: Markings, and Chapter 10: School Area Pedestrian Safety. Crosswalk markings serve primarily to guide pedestrians in the proper paths.

Pedestrian crosswalk markings should not be used indiscriminately. Unwarranted crosswalks can be detrimental to pedestrian safety by providing a false sense of security.

Replacement by highway maintenance personnel of crosswalks at intersections of local streets with State highways shall be confined to state highway surfaces. Where possible, this work should be delegated to local authorities under a cooperative maintenance agreement.

When markings are to be covered by resurfacing, the District Traffic Operations should be requested to review the project for removal of markings that are no longer necessary or are redundant.

M1.12 School Area Pedestrian Crossings

Pedestrian crosswalks and related pavement markings will be painted yellow or white, depending on the location of the school building or grounds with respect to the highway. In this regard, Section 21368 of the California Vehicle Code provides as follows:

> Whenever a marked pedestrian crosswalk has been established in a roadway next to a school building or the grounds thereof, it shall be painted or marked in yellow, as shall be all the marked pedestrian crosswalks at an intersection.
>
> Other established marked pedestrian crosswalks, may be painted or marked in yellow, if either (a) the nearest point of the crosswalk is not more than 600 feet (182.9 meters) from a school building, or the grounds thereof, or (b) the nearest point of the crosswalk is not more then 2,800 feet (853.4 meters) from a school building, or grounds thereof, there are no intervening crosswalks, other than those next to the school grounds, and it appears that the circumstances require special painting, or marking of the crosswalk, for the safety of persons attending the school.

There shall be painted or marked in yellow on each side of the street in the lane or lanes leading to all yellow marked crosswalks the following words, "SLOW--SCHOOL XING." Such words shall not be painted or marked in any lane leading to a crosswalk at an intersection controlled by stop signs, traffic signals or yield right-of-way signs. A crosswalk shall not be painted or marked yellow at any location other than as required or permitted by this section.

All school pavement delineation shall conform to Chapter 10 of the Traffic Manual: School Area Pedestrian Safety. Sign installation should be coordinated with delineation placement.

M1.13 Transverse Markings

Transverse markings which include shoulder markings, word and symbol markings, limit lines (stop bars) crosswalk lines, markings for highways patrolled by aircraft, parking stall markings and others shall be white, except for yellow markings near schools as provided in Chapter 10 of the Traffic Manual, School Area Pedestrian Safety. Transverse median markings shall be yellow.

M1.14 Parking Regulation Curb Markings

Section 21458 of the Vehicle Code authorizes the use of paint on curbs to show parking regulations. The following colors shall be used as indicated.

Red	No stopping, standing, or parking.
Yellow	Loading.
White	Stopping for loading at specified times.
Green	Short time limit parking.
Blue	Indicates parking limited exclusively to the vehicles of persons with disabilities.

Painting and maintenance of curb markings to show parking regulations is the responsibility of the local agency. An exception occurs when curb markings have been installed at the request of the State to meet traffic operational and/or safety needs. This type of work should be delegated to local agencies by means of maintenance agreements.

M1.15 Limit Lines (Stop Bars)

Limit lines (CVC377) are solid white lines, normally 12 inches to 24 inches (304.8 millimeters to 609.6 millimeters) wide, extending across all approach lanes to indicate the point behind which vehicles are required to stop.

If a marked crosswalk is in place, it would normally function as a limit line. For added emphasis, a limit line may be placed 4 feet (1.22 meters) in advance and parallel to the crosswalk line nearest approaching traffic.

In the absence of a marked crosswalk, the limit line should be placed at the desired stopping point. This point is typically no more than 30 feet (9.14 meters), nor less then 4 feet (1.22 meters), from the nearest edge of the intersecting roadway.

If a limit line is used in conjunction with a stop sign, it should ordinarily be placed in line with the STOP sign. However, if the sign cannot be located exactly where vehicles are expected to stop, the limit line should be placed at the stopping point.

A limit line shall be placed on paved approaches to state highways, and a stop pavement marking may be placed if specifically requested by the District Traffic Operations.

M1.16 Parking Stall Markings

The placement and maintenance of parking stalls is the responsibility of the local agency. An exception to the above practice may be made when a State highway-resurfacing project covers existing parking lines. In this case it is the responsibility of the Department for replacement of the parking markings. Parking stall markings shall be white. Refer to Chapter 6, Markings, of the Traffic Manual for details of parking stall layout.

M1.17 Pavement Arrows

Primary use of pavement arrows is at freeway entrance and exit ramps, turn lanes and lane reduction locations. Type of arrow and proper location can be found in Chapter 6 of the Traffic Manual: Markings.

M1.18 Railroad Crossings

Pavement markings are to be placed and maintained at all railroad grade crossings on State Highways, including spur tracks. The markings shall conform to Chapter 6 of the Traffic Manual: Markings.

Railroad grade crossing pavement markings shall also be placed in each approach lane in advance of every light rail grade crossing where automatic gates or flashing lights are present.

M1.19 Miscellaneous Markings

Instructions for proper placement and stencil design for the following markings are found in Chapter 6 of the Traffic Manual: Markings.

(A) Speed Enforcement by Aircraft

(B) High Occupancy Vehicle Lanes

(C) Bike Lane Markings

(D) Handicapped Parking Symbol

(E) Cattle Guard Crossings

Work on cattle guard crossings is to be reported to the Slopes/Drainage/Vegetation, C Family/Problem.

M1.20 Material

All pavement delineation materials used to guide or control vehicular and pedestrian traffic on the State highway system shall be approved by the Engineering Service Center, Office of Materials Engineering and Testing Services. Test sections of new materials may be placed with concurrence of Headquarters Traffic Program, New Products Coordinator.

MI.21 Traffic Paint

The two basic types of paint currently used for pavement delineation are solvent-borne and water-borne. Both types are available in white, yellow, and black.

Traffic paint is available in bulk containers called "totes" (approximately 345 gallons (1305.83 liters)), 55 gallon (208.18 liters) barrels, 5 gallon and 1 gallon (18.93 liters and 3.79 liters) containers.

Water-borne and solvent-borne traffic paints are not compatible in a striper. When the type of paint is changed, the entire striper paint system has to be thoroughly cleaned.

Waterborne paint should not be stored where it may be exposed to repetitive freeze/thaw cycling.

Suggested application rates for solvent borne traffic paint on new asphalt pavement are shown below. Two coats are required, the first light coat acts as a sealer for the asphalt and the second coat provides visibility and reflectivity. Beads are not required on the first coat unless the second coat cannot be applied the same day.

Only one coat of paint is normally required on Portland cement concrete (PCC) pavement.

Application rates will be similar to the re-striping rates for traffic stripes and the second coat guidelines for pavement markings.

When water-borne traffic paint is used, two coats of paint are not required, except on chip seals.

For chip seals, one coat of paint shall be applied in each direction of travel. Both coats shall be beaded. Care should be exercised that recommended application rates for water-borne paint are not exceeded. Applying water-borne paint too heavily will cause the paint to chip.

	Gallons (Liters) Per Mile (Kilometer)			Pounds (Kg) per Gallon (Liter) of Applied Paint
	First Painting, New Surface		Re-striping	Glass Beads
Delineation	First Coat	Second Coat	All Coats	All Coats
Broken Stripe	3-5 (11.36 – 18.93 L)	4-6 (15.14 – 22.71 L)	4-6 (15.14 – 22.71 L)	6-8 (2.72 – 3.62 kg)
Solid Stripe	6-8 (22.71 – 30.28 L)	10-12 (37.85 – 45.42 L)	10-12 (37.85 – 45.42 L)	6-8 (2.72 – 3.62 kg)
Pavement Markings	Light Application to seal pavement	1 gallon (3.785 L) per 107 sq.ft. (9.9403 m^3)		6-8 (2.72 – 3.62 kg)

Deviations from recommended application rates may occasionally become necessary to accommodate local conditions such as tracking, temperature, etc.

Decisions to adjust application rates should be based on the supervisor's knowledge of local conditions, experience, and best judgment.

To achieve maximum service life from the painted traffic stripe, striper operation should normally be conducted when weather conditions conform to the following ranges of temperature and humidity. Water-borne paint should not be applied when the ambient temperature is below 50º F (32.4ºCelsius) or when relative humidity exceeds 75º F (77.4º Celsius). Solvent-borne paint should not be applied when the ambient temperature is below 30º F (-3.6º Celsius), or when relative humidity exceeds 85º F (95.4º Celsius).

M1.22 Hot Melt Thermoplastic

Thermoplastic is supplied in two generic types, depending on the type of base resin used. The 2 types, hydrocarbon and alkyd, are not compatible in the application equipment and must never be mixed.

Both types of thermoplastic are available in granular or block form for spray, ribbon, or extruded application. The granular form is a dry blended mixture of resins, pigments, fillers, and glass beads packaged in a meltable plastic bag.

Thermoplastic for traffic stripe is available in white or yellow colors.

Thickness of thermoplastic may be reduced to achieve a better cost-effectiveness when used on pavement surfaces having a short life expectancy. The recommended minimum application rate of extruded thermoplastic is 80 miles (128.74 kilometers).

M1.23 Cold Pre-Formed Plastic Tape

Plastic tape comes as a complete stripe or pavement marking legend ready to be applied to the road. It may be surface applied recessed or rolled into the pavement on new asphalt paving projects.

This material may be considered for locations where use of tape may be cost effective compared to other alternatives. Cold weather application of tape is generally not recommended and pavement temperatures should be at least 50ºF (32.4º Celsius). Manufacturers' instructions for allowable temperature ranges should be followed.

M1.24 Thermo-Applied Granular Striping System

A flame-applied dry powder pavement delineation system, is a fast-drying material. It has a service life slightly less than paint and may be considered for use in heavy traffic areas that do not meet criteria requiring longer lasting materials.

Due to the fast drying character of this system, it works especially well in congested areas by reducing the traffic control required at locations having high traffic volumes.

The Powder material is applied using an open flame heat source, with a "Greenlite" type applicator. Special care must be taken to avoid starting fires in adjacent grass or brush.

M1.25 Pavement Markers

Pavement markers are available in various configurations and may be surface mounted (raised) or recessed. Markers can be reflective or non-reflective, temporary, semi-permanent or permanent, and can be installed using either epoxy or bitumen adhesives. All pavement markers used must be pre-approved by Headquarters Traffic Program and tested for compliance with specifications by the Office of Materials Engineering and Testing Services.

The allowable ambient temperature range for pavement marker installation varies with the type of adhesive being used. When using bitumen adhesive, it is important that adhesive temperature during application be between 375º F (617.4º Celsius) and 425º F (707.4º Celsius).

The use of epoxy adhesive requires that traffic control be maintained for protection of the marker until the final set of epoxy takes place. This may require as much as one hour of cure time.

The 1:1 mixing proportion of epoxy components must be carefully controlled to achieve the best bond between the pavement surface and bottom of the marker. Minor deviations can seriously increase marker loss. Samples of mixed epoxy should periodically be submitted to the Office of Materials Engineering and Testing Services, to assure that proportioning equipment is functioning properly.

Markers of approved colors may be placed by other agencies to identify locations of special facilities such as water sources for fire protection. Permits are required for such installations.

M1.26 Surface Preparation

(A) Paint

A mechanical sweeper may be used prior to paint application to remove debris from road surface. This operation may or may not be necessary, depending on amount of dirt/debris on the roadway surface. On new PCC, mechanical wire brush or abrasive blasting must be used to remove curing seal and other foreign material. Use of an air line (duster) mounted in front of the paint guns on the striper has proven successful in removal of dust.

Care must be taken not to use too much air and overwork the compressor. It is an unacceptable waste of maintenance resources to place paint or other delineation materials on areas where dirt, debris or weeds prevents adherence of such materials to the roadway surface.

(B) Pavement Markers

Both PCC and AC road surfaces should be clean and dry before application of adhesive. This is especially important on new PCC pavements. The contact area for markers placed over existing paint must be either abrasive blasted or the paint must be well worn to achieve a satisfactory bond.

Pavement delineation materials shall not be applied in wet weather.

M1.27 Inventory Updating

Refer to Volume 2 Chapter 4, (Highway System Inventory) for information about inventory updating.

M1.28 Supplemental Information

(A) Guidance from District Traffic Operations

District Traffic Operations should be helpful in providing current standards that can be carried on each striper and marking truck. Supervisors are responsible for assuring that the latest standards are available for performance of work. Any change in stripe or marking patterns must be in writing and approved by District Traffic Operations.

(B) Equipment Needs

Specialized equipment is required for work performed by pavement delineation crews.

The Equipment Catalog should be reviewed before submitting requests for new or replacement equipment.